Working with Data and Chance: Developing Statistical Literacy

A
Fulbright Proposal

Daniel L. Canada, Ph.D
Associate Professor, Dept. of Mathematics
Eastern Washington University

Abstract

The project enhances statistical literacy and emphasizes its centrality to civic responsibility as societies increasingly rely on statistics to make decisions or influence public opinion. One aim of the project is to share current strategies used in other countries for training preservice teachers in the area of probability and statistics. Furthermore, research in the field of statistics education has only recently begun to illuminate how preservice teachers reason about the role of variability in probability and statistics. This project also provides valuable perspective from a developing country by allowing research into the statistical conceptions held by preservice teachers in Tanzania.

Dr. Dan Canada

1. Introduction

There are two intertwined purposes of this project: The first is to share current strategies used in other countries for training preservice teachers in the area of probability and statistics, and the second is to conduct research into the conceptions that preservice teachers in Tanzania have regarding the role of variability in probability and statistics. Common to both purposes is an emphasis on actively working with data and chance, exploring what statistical literacy involves and how it has become central to civic responsibility as societies increasingly rely on statistics to make decisions or influence public opinion. In the two main sections that follow, I'll detail these purposes by first explicating the lecturing component and then the associated research component.

2. Lecturing Component

This main section is broken into two parts, with the first part highlighting more of the *professional* aspects of the lecturing component (including what is proposed and why it is of value), and the second part highlighting more of the *personal* aspects (including my own experiences and preparation).

2.1 Professional Aspects

Societies are awash in data, swimming in a sea of statistics. The public good is best served by a statistically literate populace that can analyze data effectively, whether the data is presented through advertisements from businesses or government survey results presented in the media. Certainly there has been increased curricular emphasis on probability and statistics around the world, as examples from Spain, Great Britain, Australia, New Zealand, America, and other countries attest (Batanero, Godino, Valecillos, Green, & Holmes, 1994; Shaughnessy, Garfield, & Greer, 1996; Watson & Moritz, 2000). Even as economically developing countries such as Uganda and Botswana seek to bolster curricular inclusion of statistics (Opolot-Okurut, Opyene-Elut, & Mwanamoiza, 2008; Garegae, 2008), which is hereafter in this document assumed to include probability, so too can Tanzania benefit from increased attention to these topics.

As Septimi Kitta (2004) noted, "in Tanzania, mathematics occupies a high profile in the secondary school curriculum" (p. 1). The goals of this proposal are complementary to the vision statement of the Tanzania Mathematics Advancement Centre (2005), whose aim is to help people "understand mathematics at their equivalent levels and appreciate the enormous range and importance of its applications and contribution in daily life and development" (online at http://www. tanzaniagateway.org/docs/TanzaniaMathematicsCentre.asp).
By sharing recent trends in the statistical training of teachers, one intent of this project is to equip the University of Dar es Salaam with tools for helping preservice teachers sustain work with data and chance in the classrooms where they will eventually serve.

The curricular modules I propose teaching cover a broad spectrum of major themes in probability and statistics, and include an emphasis on the incorporation of educational technology. These eighteen modules, while flexible in terms of the length and order, roughly flow from working with data (mainly collecting, representing, and interpreting) to working with chance (especially dealing with uncertainty, contrasting empirical with theoretical probabilities, and making inferences). It is not necessary to teach all the modules, as experience has shown that a subset of about ten can form the basis for the syllabus of a standard American university class of three credits (on a semester system). The more

modules taught, however, the deeper the engagement in the topics. Thus, the actual number and selection of modules would depend on the calendar requirements of the host university. Rather than give a full list and description of each of the modules, I'll highlight some of the main themes that are encompassed

When working with data, a key theme is in the questions we ask. We may wonder, for example: How long does a bus trip from Dar es Salaam to Dodoma usually take? What is the typical number of days it takes to clear imports from customs? Reputedly the students at the University of Dar es Salaam tend to be politically engaged – How true is this claim? The cycle of statistical inquiry includes asking and refining questions (Wild & Pfannkuch, 1999), and moves to a plan for gathering data: How much data is enough? How can we avoid bias? Also, the media - including advertisements as well as business and political reports - is a ripe source for graphs and statistical data that can be used in different ways to underscore paradoxical conclusions (Watson, 1997). We see that the discipline of statistics exists to make sense of data, which serve to inform us regarding questions that we find relevant, and I envision adapting modules on statistical inquiry to fit the interests of the students at the host university. In turn, teachers can encourage their own students to ask questions about their world, and how data and its interpretation can shape our perspective.

When working with chance, a key theme is in the expectations we hold. On the one hand, some probabilities are given to us and we may wonder what to expect in light of this information. If we are told that 5% of the units being manufactured are defective, then what would we expect to find in a batch 100 units? Would we be surprised to find only 1 or 2 defective units? What if we delivered several batches of 100 units to clients, and each client claimed there were over 8 defective units – Would that cause us to doubt the claim of 5% being defective? Or, is such a finding consistent with random chance? On the other hand, we may not know what the underlying probability of a phenomenon is, and can forge ways of empirically estimating this. Even adults (including trained statisticians) show deep-seated intuitive responses to reasoning about chance events, and these intuitions often lead us astray (Shaughnessy, 2006). The instructional modules I use help refine our intuitions through an iterative cycle that lets us make predictions and examine those predictions in light of emergent empirical evidence, returning again to make new (and hopefully better) predictions.

It is worth noting that these modules, which comprise what I consider a series of instructional interventions in the area of statistics education, are based on materials which I expect to leave with the University of Dar es Salaam. The modules are research-based and have been forged out of ten years of collaborative efforts spent working with both pre-service and in-service teachers (as well as with their own students), undergoing iterative refinements as they have also been implemented in the classroom.

2.2 Personal Aspects

There are several elements of my background that combine to serve as an excellent preparation for this project. Firstly, I have been teaching mathematics for over 20 years now (at middle and high school grades as well as at college levels), with experience up through the lower division undergraduate math classes such as college algebra, calculus, and introductory statistics. Most recently, I have taught mathematics content and pedagogy courses for preservice and inservice elementary and middle school teachers at Portland State University and now here at Eastern Washington University. Secondly, while at PSU I was fortunate to have worked on two different NSF grants. The first one was aimed at implementing local systemic reform in mathematics education, and involved an exploration of perceptions held by parents, teachers, and administrators. The second one involved the statistical thinking of middle and high school students, as well as that of their teachers. While

at EWU, both in-house and state-funded grants have enabled me to extend my research in probability and statistics education. Lastly, much of my own personal background makes me especially appreciative of issues of equity and culture. Having an elementary education in Zaire, a secondary education in Malaysia, plus teaching experience in Yemen and Korea, I find that I connect easily to a diverse mixture of students and teachers. Much of this experience is tied to my family: With siblings born in Kuala Lumpur, a wife born in Tangier, a daughter born in Jibla, plus parents currently teaching in Hanoi and a brother teaching in Dar Es Salaam, it's easy to see how the web of my life is spun around the globe.

Yet, for the past ten years my principal residence has been in America. After my Ph.D. studies, the road to tenure has included thesis advising and service on the department planning committee as well as chairing the mathematics education committee. On the latter two committees, I was involved in planning curricular as well as larger structural programmatic changes, and this experience can serve the University of Dar es Salaam as it seeks external perspective on its own academic programs and curriculum. For my own benefit, I eagerly anticipate bringing back fresh perspectives on teaching and learning from another culture as I integrate these perspectives into my practice at my home institution. Certainly EWU (where I currently serve) can benefit from any and all efforts to increase exposure to diversity in the training of its teachers.

3. Research Component

This main section explicates research that I propose to conduct into the conceptions that preservice teachers in Tanzania have regarding the role of variability in probability and statistics. The research is connected with the lecturing themes articulated earlier, and will be presented in terms of its *background and significance*, *objectives and methodology*, and also *timeline and products*.

3.1 Background and Significance

As established earlier in this proposal, worldwide attention to the curricular inclusion of probability and statistics has been increasing (Shaughnessy, 1992). Concomitantly, has research looked at different aspects of statistics education such as notions of randomness, graph sense, or the meaning of an average value (e.g., Batanero & Serrano, 1999; Friel & Bright, 1996; Mokros & Russel, 1995). However, relatively less research has been done on the concept of variation, or variability in data, despite the centrality of variation to the entire discipline of statistics (Pfannkuch, 1997; Wild & Pfannkuch, 1999; Pfannkuch & Wild, 2001). As Torok and Watson (2000) summarized the situation, "an appreciation of variation is central to statistical thinking, but very little research has focused directly on students' understanding of variation" (p. 147).

Within the statistics education community, variation "does not mean an understanding of 'standard deviation' but of something more fundamental - the underlying change from expectation that occurs when measurements are made or events occur" (Watson, Kelly, Callingham, & Shaughnessy, 2003, p. 2). For example, the amount of change in your pocket may differ from day-to-day, and even the number of red lights you encounter on your drive to school varies. We live in a world filled with variation, yet much of the standard curricula focuses mostly on simply finding probabilities, graphing data, or finding descriptive measures such as a mean, median, or mode (Shaughnessy, 1997). More attention to variation, or variability in data, better prepares students to interpret real-life situations that are largely characterized by uncertainty (Makar & Canada, 2005).

Research that has been emerging on conceptions of variation has predominantly been conducted with students in grades 3-12 (e.g., Shaughnessy & Ciancetta, 2001; Lee, 2003; Ben-Zvi & Garfield, 2004, Reading & Shaughnessy, 2004), and far less has been published concerning the reasoning of the teachers of those students. Shaughnessy (2001) wrote that "we are not aware of any research studies that have dealt specifically with teachers' conceptions of variability" (p.1), and since that time teachers' conceptions of variation have previously been studied by only a handful of researchers (e.g., Watson, 2001; Mickelson & Heaton, 2003; Makar & Canada, 2005). If a goal is for teachers to provide students with authentic, inquiry-based tasks meant to develop children's reasoning about variation, then a natural step in achieving this goal is to improve teacher training courses (Canada & Makar, 2006). The current project, representing an expansion of my ongoing published research, helps fill an acute need for published research results on the topic of conceptions about variation held by preservice teachers.

3.2 Objectives and Methodology:

The specific purpose of the current project is to explore the development of preservice teachers' conceptions of variation as they reason about distributions of data and make inferences. The idea of comparing distributions and using variation in making inferences has been encouraged by scholars in the statistics education community, who note that "little research, whether qualitative or quantitative, has been published to date in this area" (Jolliffe & Gal, 2004, p. 6). The current project addresses the following two central research questions:

i. What aspects of variation are considered by preservice teachers in making inferences based upon a distribution?
ii. How do preservice teachers reason about variation when comparing two or more distributions?

The subjects (the preservice teachers themselves) come from the classes that I either teach or co-teach, and the delicate balance of teacher-as-researcher is something that I have had over six years of experience in achieving. This project will employ a mixed-method design (Creswell, 2002), meaning the project will provide a quantitative backdrop of how preservice teachers think about variation (using data from written responses), against which some qualitative examples will be accentuated and described in depth (using data from class observations and individual interviews).

The general methodological trajectory which I have employed in the past and will use in this project is to first obtain written responses prior to beginning formal instructional interventions. This is done using Pre-Surveys to map out the subjects' initial thinking on a range of tasks covering statistical thinking. Using an iterative cycle of analyzing written data, forming interview questions to explore with a subset of representative subjects, and then conducting instructional interventions using the modules described earlier, I am able to refine new written tasks (Post-Surveys) and interview questions to more deeply explore a subjects' thinking. Also, the modules themselves can be modified to bring more emphasis to particular aspects of thinking about variation and distributional reasoning, depending on the ongoing analysis of emerging data. This iterative cycle repeats itself through as many modules as I am able to incorporate over a course or courses, and thus the exact depth and extent of the research would depend largely on the academic calendar structure at the host university. I would expect to adapt the tasks and modules by incorporating contexts that reflect local political and cultural concerns, which is particularly apropos in the area of statistics.

While I am able to bring materials for the lecturing component to the host country and leave them behind, I would need to bring the equipment I use in the research component back

with me. This equipment includes my digital camera and video recorder, several digital voice recorders, boundary microphones, and the laptop where I edit audiovisual data as well as store transcribed written data. All of my data collection and analysis has depended on this set of tools. In analyzing the emerging corpus of data, comprising written data as well as videotapes of selected class lessons and individual interviews, a conceptual framework will be used which has come from my prior research (Canada, 2006). This framework provides a lens for looking at how people are *expecting*, *displaying*, and *interpreting* variation. While it has proved a flexible framework useful for analyzing responses from middle- and high-school students, as well as inservice and preservice teachers, all of the research that I have done with to date has been conducted in America. Thus, focusing on preservice teachers in Tanzania affords a valuable opportunity to examine the utility of the framework of analysis in other cultures.

3.3 Timeline and Products

The full span of research and teaching which I propose entails approximately ten months. The teaching portion can be accomplished in one semester, and can include regular lectures as well as specific colloquia that can be delivered in forums such as that hosted by the Mathematics Association of Tanzania. The research portion can take place concurrently with the teaching, and any extra time that spent in the host country would be devoted to ensuring accurate transcriptions of written and verbal data, and also to drafting the preliminary manuscripts which would be submitted to journals and conferences. Ideally I can partner with faculty of the host institution to initiate the collaboration on the writing of these papers. It is important to note that, while initial analysis of the data occurs during the teaching of the modules (to help inform subsequent lecturing and research activity), a second and more detailed phase of analysis occurs as data gets transcribed and imported into a qualitative software package which I have used to derive, refine, and support my analytical framework. Thus, it is likely that analysis will continue as I reflect upon and mine the data even after I have left the host country. Other work that will be initiated but likely unfinished by the time I return home would include a full collection of edited video clips of class interactions and discussions that highlight reasoning about variability.

My publishable end products for this project include at least two papers submitted to a conference having peer-reviewed proceedings (such as the International Conference on Teaching Statistics or the International Group for the Psychology of Mathematics Education) and also two papers submitted to a research journal, (such as the Statistics Education Research Journal or Educational Studies in Mathematics). Additionally, I would apply to present at forums aimed at sharing educational experiences across cultures; these forums exist locally among the three major universities in my immediate area, and also I envision being invited to share at a regional and national level through my affiliation with the National Council of Teachers of Mathematics.

4. Conclusion

Combining my earlier personal background of overseas learning and teaching with my more recent scholarly experience in academia constitutes an ideal opportunity for me. More important is the belief that stronger reasoning about data and chance equips people to make sense of information in any society, and that working alongside preservice teachers at the University of Dar es Salaam can make a positive contribution. Certainly the field of statistics education will benefit powerfully from this project, since little is known about the conceptions of variation held by preservice teachers in developing countries like Tanzania.

Dr. Dan Canada

Addenda

This addenda provides more specifics regarding Mathematics Education in Tanzania.

First, there are local organizations specifically dedicated to promoting the educational aspects of the discipline of mathematics. In the Annual Meeting of the Mathematics Association of Tanzania, for example, which is held this year at the University of Dar es Salaam, there are to be discussions on curricular issues "identified by practicing teachers to be challenging to teach and learn" as well as "exhibitions and demonstrations on the use of mathematics teaching aids" (online at http://www. maths.udsm.ac.tz/mat/news.htm). My work would seem to fit in nicely at such a forum. The mission of the Tanzania Mathematics Advancement Centre is "to improve performance in mathematics and its application by using studying approaches that will build positive attitude, confidence and interest towards the subject" (online at http://www. tanzaniagateway.org/docs/TanzaniaMathematicsCentre.asp), which also echoes my own purposes.

Second, reports from regional government or government-sponsored agencies also echo themes that relate to the importance of Mathematics Education. In a working report on the quality of Tanzanian education by the Southern and Eastern Africa Consortium for Monitoring Educational Quality (SACMEQ), authors from the Tanzanian Ministry of Education and Culture issued a comprehensive list of recommendations in their agenda for action. Among these were a call for more teacher education in mathematics, with an emphasis on keeping "abreast with the changing demands of the curriculum as well as the needs of learners and society" (Mrutu, Ponera, and Nkumbi, 2005; online at http://www.sacmeq.org/ education-tanzania.htm). Also, through UNESCO's Basic Education in African Programmes (BEAP), the Tanzanian Institute of Education joined other African countries in assessing curricular and teacher development needs. A specific objective of BEAP in Tanzania, issued in April, 2009, includes the incorporation of the "latest curriculum related initiatives and research…enhancing learning, life skills, mathematics, science and technology education" (online at http://www.ibe.unesco.org/fileadmin/user_upload/COPs/News_documents/2009/ 0904BEAP_Tanzania/Draft_TOR_for_BEAPTanzania_Conference_Presentations.pdf). Again, the objectives articulated in these reports are consonant with those of my proposal.

Finally, I have also found some recent scholarly papers related to Mathematics Education in Tanzania. Examples include the work of Verdiana Masanja of the Mathematics Department University of Dar es Salaam, (e.g. "Gender Disparity in Science and Mathematics Education", 2004; online at http://www.hbcse.tifr.res.in/episteme/ episteme-1/themes/ vedianamasanja%20modified.pdf), as well as the enlightening doctoral dissertation of Septimi Kitta (2004) on the pedagogical content knowledge of Tanzanian teachers. Although the Dutch University of Twente issued Kitta's degree, I note that a faculty member of University of Dar es Salaam (Dr. Osaki) was also on the doctoral committee. I'd be interested in contacting these people for further information and ideas on potential collaboration.

In summary, there seems to be a well-established interest in Mathematics Education in Tanzania. Given this environment, I expect to be able to forge connections that can be mutually rewarding in the promotion of improved mathematical teaching and learning for all. This aspect of equity and access to mathematics is a hallmark of my own perspective as well as that of my country's National Council of Teachers of Mathematics. And, from what I have read so far, it is also a perspective shared in the United Republic of Tanzania.

Bibliography

Batanero, C., Godino, J., Valecillos, A., Green, D., & Holmes, P. (1994). Errors and difficulties in understanding elementary statistical concepts. *International Journal of Mathematical Education in Science and Technology, 25* (4), 527-547.

Batanero, C., & Serrano, L. (1999). The meaning of randomness for secondary school students. *Journal for Research in Mathematics Education, 30*, 558-567.

Ben-Zvi, D. & Garfield, J. (Eds.) (2004). Special issue: Research on reasoning about variability. *Statistics education research journal 3*(2).

Canada, D. (2006). Enhancing Elementary Preservice Teachers' Conceptions of Variation in a Probability Context. In A. Rossman & B. Chance (Eds.), *Working Cooperatively in Statistics Education. Proceedings of the 7th International Conference on Teaching Statistics.* Salvador, Brazil.

Canada, D., & Makar, K. (2006). *Preservice Teachers' Informal Descriptions of Variation*. Paper delivered at the 2006 Annual Meeting of the American Education Research Association. San Francisco, CA.

Creswell, J. (2002). *Research Design: Qualitative, Quantitative and Mixed Method Approaches.* Thousand Oaks, CA: Sage Publications, Inc.

Friel, S., & Bright, G. (1996). *Building a theory of graphicacy: How do students read graphs?* Paper presented at the American Educational Research Association, NewYork, NY.

Garegae, K. (2008). Training Statistics Teachers for Botswana Senior Schools: Is it Necessary? In C. Batanero, G. Burrill, C. Reading, & A. Rossman (Eds.), *Joint ICMI/ IASE Study: Teaching Statistics in School Mathematics. Challenges for Teaching and Teacher Education. Proceedings of the ICMI Study 18 and 2008 IASE Round Table Conference.* Monterrey, Mexico: International Association for Statistics Education.

Jolliffe, F., & Gal, I. (2004). Editorial. *Statistics Education Research Journal, 3* (2), p. 6.

Kitta, Septimi. (2004). *Enhancing Mathematics Teachers' Pedagogical Content Knowledge and Skills in Tanzania.* Unpublished doctoral dissertation, University of Twente. [Online at http://doc.utwente.nl/41421/].

Lee, C. (Ed.) (2003) *Reasoning about variability: A collection of current research studies. (Proceedings of the Third International Research Forum on Statistical Reasoning, Thinking, and Literacy)*. Mt. Pleasant, MI: Central Michigan University.

Makar, K., & Canada, D. (2005). Preservice Teachers' Conceptions of Variation. In Chick, H. L., & Vincent, J. L. (Eds.) *Proceedings of the 29th Conference of the International Group for the Psychology of Mathematics Education*. Sydney, Australia: PME.

Mickelson, W. & Heaton, R. (2003). Purposeful statistical investigation merged with K-6 content: Variability, learning and teacher knowledge use in teaching. In C. Lee (Ed.) *Proceedings of the Third International Research Forum on Statistical Reasoning, Thinking, and Literacy (CD-ROM).* Mt. Pleasant, MI: Central Michigan University.

Mokros, J., & Russell, S. (1995). Children's concepts of average and representativeness. *Journal for Research in Mathematics Education, 26* (1), 20-39.

Opolot-Okurut, C., Opyene-Elut, P., & Mwanamoiza, M. (2008). The Current Teaching of Statistics in Schools in Uganda. In C. Batanero, G. Burrill, C. Reading, & A. Rossman (Eds.), *Joint ICMI/IASE Study: Teaching Statistics in School Mathematics. Challenges for Teaching and Teacher Education. Proceedings of the ICMI Study 18 and 2008 IASE Round Table Conference.* Monterrey, Mexico: International Association for Statistics Education.

Pfannkuch, M. (1997). Statistical thinking: One statistician's perspective. In F. Bidduch & K. Carr (Eds.), *Proceedings of the 20th Annual Conference of the Mathematics Education Research Group of Australasia* , (pp. 406-413). Rotorua, NZ: MERGA.

Pfannkuch, M., & Wild, C. (2001). What do we know about statistical thinking? Overview of statistical thinking, a literature review. In C. Reading (Ed.), *Background Readings for the Second International Research Forum on Statistical Reasoning, Thinking, and Literacy* , Armidale, Australia.

Reading, C., & Shaughnessy, J.M. (2004). Reasoning about variation. In D. Ben-Zvi & J. Garfield (Eds.), *The Challenge of Developing Statistical Literacy, Reasoning and Thinking* (pp. 201-226). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Shaughnessy, J. M. (1997). Missed opportunities in research on the teaching and learning of data and chance. In F. Bidduch & K. Carr (Eds.), *Proceedings of the 20th Annual Conference of the Mathematics Education Research Group of Australasia*, (pp. 6-22). Rotorua, NZ: MERGA.

Shaughnessy, J. M. (2001). *The Development of Middle and Secondary School Students' Conceptions of Variability.* Proposal for NSF Grant No. REC 0207842. Portland, Oregon: Portland State University.

Shaughnessy, J. M. (1992). Research in Probability and Statistics: Reflections and Directions. In D.A. Grouws (Ed.), *Handbook of Research on Mathematics Teaching and Learning,* (pp. 465-494). New York, NY: Macmillan.

Shaughnessy, J.M. (2006). Research on Statistics Learning and Reasoning. In F. Lester (Ed.), *Second Handbook of Research on Mathematics Teaching and Learning* (pp. 957-1009), Charlotte, NC: Information Age Publications.

Shaughnessy, J. M. & Ciancetta, M. (2001). Conflict Between Students' Personal Theories and Actual Data: The Spectre of Variation. Paper presented at the Second Roundtable Conference on Research on Statistics Teaching and Learning, Armidale, New South Wales, Australia.

Shaughnessy, J., Garfield, J., & Greer, B. (1996). Data handling. In A. Bishop, K. Clements, C. Keitel, J. Kilpatrick, & C. Laborde (Eds.), *International Handbook of Mathematics Education (Part 1),* (pp. 205-237). Dordrecht, The Netherlands: Kluwer.

Torok, R., & Watson, J. (2000). Development of the concept of statistical variation: An exploratory study. *Mathematical Education Research Journal, 12* (2), 147-169.

Watson, J. (1997). Assessing statistical thinking using the media. In I. Gal & J. Garfield (Eds.), *Handbook of Assessment in Statistics Education,* (pp. 107-121). Amsterdam: IOS Press and the International Statistical Institute.

Watson, J. (2001). Profiling teachers' competence and confidence to teach particular mathematics topics: The case of chance and data. *Journal of Mathematics Teacher Education 1* (2), 1-33.

Watson, J., Kelly, B., Callingham, R. & Shaughnessy, J. M. (2003). The measurement of school students' understanding of statistical variation. *The International Journal of Mathematical Education in Science and Technology.* (34), 1-29.

Watson, J., & Moritz, J. (2000). Developing Concepts of Sampling. *Journal for Research in Mathematics Education, 31* (1), 44-70.

Wild, C., & Pfannkuch, M. (1999). Statistical thinking in empirical enquiry. *International Statistical Review, 67,* 233-265.

Dr. Dan Canada

The following pages represent a composite of actual syllabi and course outlines that I have used in teaching similar classes both at Portland State University (1998-2003) and Eastern Washington University (2003-2009). The classes have been adapted to suit either undergraduate preservice teachers or graduate inservice teachers, and selected components have also been used during professional development workshops and in the course of national- and state-funded grantwork.

TERMS 1 & 2 MATH SYLLABI

Working with Data / Working with Chance

Dates and Times : MTWRF (10:00-11:50)
Location: KGS 233

Instructor: Dr. Daniel L. Canada
Office: KGS 203

OVERVIEW

During these two terms, we will study conceptual approaches to Statistics & Probability. Additionally, we will focus on strands woven throughout the math curriculum, such as pattern recognition and problem solving strategies.

These topics are motivated or derived primarily from the course packet provided. This material will be supplemented by other sources as needed.

GOALS

By discovering and honoring the mathematician within you, goals include the continued development of your:

- Mathematical knowledge and concept understanding
- Ability to reason and communicate mathematically
- Confidence in problem solving
- Ability to invent mathematical procedures and make generalizations
- Understanding of the mathematical thinking of others

GRADING

Each Term Grade is determined as follows:

Attendance	=	5%
Homework Assignments	=	15%
Quizzes (2 at 10% each)	=	20%
Exams (2 at 15% each)	=	30%
Final Exam	=	30%
		100%

The scale used in determining grades is the standard printed on the next page.

Dr. Dan Canada

POLICIES

The assignments are due on the date provided in class; late work is not accepted. Again, *expect no credit on work which is not turned in on time.* Also, since make-up exams and quizzes are not provided, the following dates are provided for your planning purposes:

TERM 1

Quiz 1 : Jan. 24	Exam 1 : Feb. 07	Quiz 2 : Feb. 21	Exam 2 : Mar. 06

(The date and time for the comprehensive final exam is Thursday, March 20, at 9:00 am.)

TERM 2

Quiz 1 : Apr. 15	Exam 1 : Apr. 29	Quiz 2 : May 13	Exam 2 : May 27

(The date and time for the comprehensive final exam is Monday, June 6, at 9:00 am.)

Again, *if you do not show up for a quiz or exam, expect to receive no credit.* Any questions can be brought to my office hours (MTRF 1:00-1:50 & by appointment). My office space is in KGS 203, my email address is *dcanada@ewu.edu* , and phone messages may be left at 359-6074.

GUIDELINES

- Attendance

  One point is earned for each day of attendance in which role is taken and you are present and participating.

- Homework Assignments

  Solutions to problems and activities will be collected on due dates announced in class. Work on these assignments may be done independently or with others, but each of you must write up your own solutions (unless otherwise instructed). These should be done neatly, completely, and correctly, and will be graded on those attributes.

- Grading Scale

  The scale used in determining grades is as follows.

00-61%:	0.0	70%	: 1.5	79%	: 2.4	88%	: 3.3
62%	: 0.7	71%	: 1.6	80%	: 2.5	89%	: 3.4
63%	: 0.8	72%	: 1.7	81%	: 2.6	90%	: 3.5
64%	: 0.9	73%	: 1.8	82%	: 2.7	91%	: 3.6
65%	: 1.0	74%	: 1.9	83%	: 2.8	92%	: 3.7
66%	: 1.1	75%	: 2.0	84%	: 2.9	93%	: 3.8
67%	: 1.2	76%	: 2.1	85%	: 3.0	94%	: 3.9
68%	: 1.3	77%	: 2.2	86%	: 3.1	95-100%:	4.0
69%	: 1.4	78%	: 2.3	87%	: 3.2		

Note that the cut-off point for the 2.0 mark is at 75%.

Dr. Dan Canada

STATEMENT OF TEACHING PHILOSOPHY

I share this with all my students to encourage them to reflect on their own practice

---

While I have compiled a written philosophy of teaching several times in the past, twenty years' of teaching shows me that such a philosophy evolves over time. I view this evolution as a positive thing, and welcome the chance to reflect and articulate my views afresh. Good teaching takes into account many things, but in this statement I'll comment on only two: The diversity of the students and the role of the teacher.

In considering my students, certainly they come with a range of different educational backgrounds. Their learning styles are different. Some are quite adept symbolically, while others are more verbal. Some can write at length about what they are thinking, while others prefer to draw pictures. Particularly when it comes to group work, reactions run the gamut from those who have only worked by themselves to those who thrive in a social learning environment. They also have different attitudes towards mathematics, ranging from those who love and enjoy it to those who hate and fear the discipline.

Faced with such a diversity of students, the role and attitude of the teacher is crucial for success in the classroom. For people who have taken my classes, seen me teach, or just known me for any length of time, it becomes clear that I am absolutely passionate about not only mathematics, but also the teaching of mathematics. The energy and enthusiasm I bring to the class are simply innate. My role in the classroom, however, is not to create students who are like-minded in their love of math, but rather to create an environment within the classroom wherein all students can succeed in achieving their own mathematical goals. Some techniques I use include bringing in alternate explanations, using small groups and whole-class discussions, and also mining the students' own reasoning and getting them to communicate their explanations. My attitude is that there is much we do learn from each other, and I truly validate the efforts made by my students in articulating their thinking process.

Good teaching is not merely about the teacher; it is also about the students. After years of teaching, I am no longer surprised at the fact that students continue to show me new ways to look at problems, but I am always encouraged by this phenomenon. In many ways, I am as much of a learner as my students. I learn about them, and how they come to know and understand mathematics; this learning changes with every single class with which I work. I also learn about my own teaching, and how to continue to refine my practice. This aspect of good teaching – that it stays in flux, being renewed and refreshed through reflective practice – is what has made this a dynamic and expanding profession for me.

Dr. Dan Canada

COURSE OUTLINE : WORKING WITH DATA

[Module 1] Four Questions: What's Typical?

In a Nutshell

With a focus on single data sets, we'll gather numeric and categorical data to gain information about a number of different questions. The different types of displays offer different windows through which to view the data. The utility of a display often depends on why we're looking at the data to begin with. This connects to our overall philosophy that *all* portions of the solution process – numeric, table, graphic, and visual – must be connected to each other and back to the original problem context. The solution *must make sense* within the context of the task.

The Big Ideas

Often the statistics presented in school curricula are reduced to a descriptive "collect-and-present" set of skills, such as finding the mean, median, mode. Much time is spent on how to make graphs of different types. But the key dispositions in working with data are embodied in thinking like a "Data Detective" – Why are we looking at this? What questions can we ask? What do we notice? What do we wonder about? This notion of interrogating a data set is consistent with a basic framework for working with data first presented by Curcio (1987). According to this framework, students need to move beyond simply reading the data to reading *beyond* the data, which requires "extension, prediction, or inference" (Curcio, 1987, p. 384). In particular, this Module gets at the natural tension between using measures of center (mean, median, mode) and measures of spread (such as range or subranges) in trying to represent a set of data.

[Module 2] Body Measurements & Astronaut Suits

In a Nutshell

Putting a new twist on the "What's Typical?" theme, we wonder what the class data look like for various body measurements (Armspan, FootLength, etc) as well as trying to summarize repeated measurements taken for a given person (the "Astronaut"). Note that the focus is more on continuous data (measurements of length, for example) as opposed to discrete data such as the number of pets in a household.

The Big Ideas

One big idea is on the source of variability, and in this case the theme of variation in measurement is central to this investigation. As everyone takes the measurement of the "Astronaut" , it becomes apparent that the data varies : What does this suggest about the "true" armspan of this person? Measurement, by it's nature, is inherently variable: How the variability in measurement for one single person has a lot to do with how we interpret the findings for the whole class.

[Module 3] What's Faithful about Old Faithful?

In a Nutshell

Primarily using the "wait-time" (time interval between eruptions) for Old Faithful data, the initial question concerns making a prediction for about how long a person could be expected to wait until the next eruption of the geyser. While many statistics educators have used this data set or similar ones (such as wait-time for volcano eruptions), this Module most directly reflects the treatment as described in the *Mathematics Teacher* (Shaughnessy & Pfannkuch, 2002).

The Big Ideas

One big idea is on identifying trends in data, and finding the "signal" amidst the "noise" (Konold & Pollatsek, 2002). The Old Faithful data is characterized by considerable variation, and representations of this data (such as BoxPlots) reveal very little about the true nature of the phenomena; namely, that the collection of wait-times are bimodal and oscillating. Also, a time-series graph shows an alternating short-long pattern in the data. Although looking at just only one eruption at a time suggests that "Old Faithful is not faithful at all" (Shaughnessy & Pfannkuch, 2002, p. 258), the overall distribution gives a "signal" that is distinctive and useful.

[Module 4] Comparing Data Sets of Equal Sizes

In a Nutshell

In Modules 1 – 3, most of the attention was on a single data set at a time: What's typical for the number of pets? How can we characterize the class pulse rates? When we show up to see Old Faithful, how long might we wait for an eruption? Now we turn exclusively to the question of comparing two data sets from different populations: Using data that presents the lifespan of batteries for two different brands, we wonder which brand lasts longer and examine reasons for our conclusions. The samples in this Module 4 are of equal size, and in Module 5 the case of unequal sizes of samples is addressed.

The Big Ideas

Distributional reasoning comes to the forefront of the discussion in comparing data sets. That is, it quickly becomes apparent that any single aspect of a distribution (e.g. centers, spread, or shape) by itself may be a poor basis for a comparison. Deciding how similar or different data sets are "depends on an understanding of the distribution for each data set" (Bright, Brewer, McCain, & Mooney, 2003, p. 31). Distributional reasoning in this sense can be taken to mean treating data as an *aggregate* as opposed to looking at individual data points (Konold & Higgins, 2002). By integrating aspects of center, spread, and shape, we can make comparisons of distributions that are based on richer arguments than could be made by using a single aspect.

[Module 5] Comparing Data Sets of Unequal Sizes

In a Nutshell

Modules 4 & 5 both explicitly consider the question of comparing two data sets from different populations. Whereas the two data sets of Module 4 are of equal size, in Module 5 they are of unequal sizes. The main investigation outlined in the *Procedure* is two compare two drugs in terms of which gives faster relief from migraine headaches – Drug A (tested on 106 patients) or Drug B (tested on 47 patients). This is distilled from Chapter 3 of *Navigating through Data Analysis in Grades 6-8* (Bright, Brewer, McCain, & Mooney, 2003).

The Big Ideas

All of the *Big Ideas* from Module 4 also come into play for this Module as well, with the key distinction being the inadequacy of *additive reasoning* when comparing data sets of different sizes. It may be that the students naturally gravitated towards proportional reasoning in earlier Modules (and note how the use of BoxPlots in Module 4 provides a context for discussing quartiles, for example), but in fact "when two data sets have equal Ns, additive reasoning may be adequate" (Bright, et. al, 2003, p. 31). People often compare data sets by focusing on specific values (e.g. how the maximums or minimums compare) or partitioning (e.g. counting the number of batteries below a certain cut-off value). However, for data sets with unequal Ns, *multiplicative reasoning* is required (e.g. there would be a need to compare proportions of data falling within a certain interval instead of attending to mere counts). Thus, the use of unequal Ns in comparing data sets ties in nicely with the focus on moving students from *additive* to *multiplicative* reasoning.

COURSE OUTLINE : WORKING WITH DATA

[Module 6] Known Mixture

In a Nutshell

One intent of Modules 1 - 5 is to build an appreciation for data that explicitly draws attention to variability, a key component in statistical analysis. Here in this Module, the Known Mix draws on the basic notion of a sampling from a known population: There are known to be 70 Yellow and 30 Green chips in the jar, and we intend to pull out a handful of 10 chips and count the Number of Yellow in our handful. With replacement, actually we'll pull out a total of thirty of these handfuls and consider the "Number of Yellow" in each of these handfuls. Because this activity incorporates ideas from previous Modules and also essentially springs from the basic notion of probability as (Good Outcomes) / (Total Possible Outcomes) , this is actually a nice segue from the more statistically-focused Modules 1-5 to those 6-10 which are more in line with a frequentist interpretation of probability.

The Big Ideas

A question on the 1996 NAEP which we'll call the *Gumball Task* began what is now a well-established line of research into stochastical reasoning (here we take the common European use of the term "stochastics" to mean both probability and statistics). On the NAEP, students were asked this kind of question: If they drew 10 gumballs from a 70 Yellow – 30 Green mix, then how many of the 10 would they expect to be Yellow? While assessing proportional reasoning in thinking of a "7 Yellow" answer, the test-makers nonetheless missed a major opportunity in extending the thinking about probability (Shaughnessy, 1997).

Instead, researchers began to extend the *Gumball Task*, asking questions more like "Suppose you did this five times (replacing and remixing the gumballs each time), then what you expect to get?" (e.g. Shaughnessy, Watson, Moritz, & Reading, 1999)

At least two big related ideas for stochastical thinking are involved in repeated-sampling: One idea is the "Outcome Approach" (Shaughnessy, 1992) which describes a bias people often have whereby they see the nature of probability as requiring them to predict the result of single trial. The other idea involves the way that the sense variability arising from probabilistic or sampling situations is often overridden by people's desires to anchor themselves to a central statistic, a point estimate, or a theoretical probability (Shaughnessy, 1992). In essence, the conflation of these two ideas can be described in this context with the following composite of a typical response to drawing a handful of 10 five times (replacement assumed from now on):

> *"Well, if I drew just one chip it would have a 70% chance of being Yellow. So if I drew 10 chips, that handful should have 0.70 x 10 = 7 Yellow chips. But if one handful of 10 was supposed to have 7 Yellow chips, then so would the second handful, etc. So I think 7, 7, 7, 7, 7 is the best choice to put for what I'd get in five handfuls."*

Such a response is quite typical for those operating under the Outcome Approach, or for anyone where variability is not a part of their thinking. Other established misconceptions also come into play (such as *representativeness*, from the work in the 70s and 80s on heuristics and biases stemming from research on intuitive reasoning under uncertainty. For a useful summary, see Shaughnessy (1992). In one sentence: Even though you "know" the probability of "70%", what does this mean for variability in the outcomes for these 30 trials?

[Module 7] Mystery Mixture

In a Nutshell

Whereas Module 6 revealed and discussed the "Known Mixture" ahead of time before drawing samples, here in "Mystery Mixture" the only thing revealed is that there are 1000 chips of a Yellow-Green mix in what we called the LargeJar (as opposed to the 100 chips in the SmallJar for the "Known Mixture"). We're also told that all the small groups have identical Large Jars (the "Mystery Mixture" is the same for all). Allowing wide parameters as far as *what* kinds of samples they want to draw (and *how many*), the teams then do their sampling and describe "What they think for the True Mixture". We leave it fairly open-ended, with variations being questions like "How many Yellows are in the Jar?"

The Big Ideas

One great idea from "Known Mixture" is that *even if you know ahead of time* what is in the SmallJar, the samples drawn are going to vary. Now we'll think in reverse: Given a bunch of sample results, and knowing that they vary from some proportion, what then can we say about the "True Proportion" ? A major concept that stochastic education researchers are wrestling with at the moment is the notion of *informal inference* : In the case of the "Mystery Mixture" for a secondary school level, think about how students may want to call out "point estimates" for this LargeJar: *"I think there's 578 Yellow and 422 Greens! Am I right???"* Where does this instinct for right/wrong guesses for single numbers come from? Why not statements like : *"I'm pretty sure it's somewhere between 550 and 650*

Yellows" or *"The data seems to suggest it would be more than 56% Yellow"* and what about informal statements of confidence in what a person claims for the True Mixture? Like the "Known Mixture", this Module about the "Mystery Mixture" offers many avenues to really explore the interconnections between probability and statistics.

[Module 8] River Crossing Game

In a Nutshell

At its core, this game involves the distribution of the sums for a pair of regular dice. Designed for two-person games, the idea is that each player gets an equal number of chips to places on the possible outcomes for sums (2, 3, ...12). As the dice are thrown, players get to remove chips that occupy the resultant sum – Whoever gets to remove all their chips first is the winner. However, despite its seemingly simple premise, this game teases out major themes involving not only theoretical probability, but the variability inherent in random events.

The Big Ideas

Moving students to an understanding that a probability of getting a sum of "3" is actually 2/36 is no trivial matter, since there is the issue of rolling "2"+"1" being a physically distinct event from "1"+"2". Yet, even once the theoretical distribution is "known" there are a couple of big questions: First is the issue of what that distribution really means. for instance, since "7" is the sum with the highest likelihood, would we therefore put all our chips on that "7" spot? Students rarely do this intuitively, since they sense they could get sums other than "7", so again the spectre of variation arises. Second, it isn't clear what the optimal chip placement would be for only 12 chips, for example, even with a knowledge of the theoretical distribution of sums. A question which has also arisen in a class situation is how long any given game might last (that is, how many rolls of the dice might be needed).

[Module 9] Sixty Tosses

In a Nutshell

In thinking about the distribution of 60 tosses of a regular die across the resulting faces (that is, "How many times out of 60 will each side be face-up?"), this activity fundamentally addresses uniform distributions. After making predictions for the six outcomes (i.e. how many "1"s and how many "2"s, etc), subjects are then shown four lists of supposed outcomes and asked for their reaction.

The Big Ideas

This activity is a good one to place early on in Probability & Statistics module, since it is very simple in some respects, but also very deep in that it squarely focuses on two big issues: The first big issue is once again the variability in smaller samples, again tying this in with randomness and the meaning of probability. Since for only 60 tosses there will be variation that markedly distinguishes actual results from the theoretically "uniform" idea, people become attenuated to "how much variation" is realistic. The second big issues concerns our internal biases and beliefs about decision making under uncertainty – People who might sound more certain in making predictions ahead of time are also apt to questions those predictions in hindsight (especially if they think somebody else made that same prediction).

Dr. Dan Canada

In a Nutshell

Turning to problems that involve conditional probability, the aim here is twofold: First, we look at separate situations, and then we look at the collection of situations (noting how the situations are similar and different). The set of tasks deliberately tries to take a minimalist approach, using "small" numbers of events (such as the prerequisite tossing of two coins) and the accompanying "small" fractions (e.g. Prob{2^{nd} Coin H | 1^{st} Coin T} = 1/2 or is it 1/3 or 1/4 ?). Ultimately, simulations can also serve a purpose in "convincing" secondary schoolers.

The Big Ideas

As Shaughnessy wrote, "the difficulties students have with conditional probabilities and with concepts of independent events have been written about by a number of mathematicians and statistics educators" (1992, p. 472). He then goes on to cite over 14 separate references, but especially prolific in this area is Ruma Falk (e.g. 1988). In fact the "Falk phenomenon" (Shaughnessy, 1992) is described in the literature, using the following example:

> *A box has 2 White & 2 Black balls in it. You draw one, keep it, then make a second draw. Q1> What is P(2^{nd} Draw White | 1^{st} Draw White) ?*
> *Q2> What is P(1^{st} Draw White | 2^{nd} Draw White) ?*

Falk and others talk about how Q1 is easier for students to relate to as "1/3" but they will find difficulty in seeing or even believing that Q2 is also "1/3" , and reasons for these and other conundrums in reasoning are plentiful in the literature. The notion of "What is the conditioning event ?" is often difficult to make sense of. Where can this leave secondary students, for whom conditional probability is on the fringes if at all on the implemented curriculum? For one, there is a deeper issue of interpretations of probability from a subjective versus frequentist perspective (Batanero, Green, & Serrano, 1998) – Certainly it is understandable for one to *feel* differently about likelihoods based on more or less information revealed, but how does the uncovering of information (i.e. the conditioning event) change the interpretation of the probabilities? For teachers, these are issues that can be addressed by immersing in them in the swamp of persuasive arguments – some viable, some not, and some questionable – that their students will use in reasoning about these classic situations. And certainly all of these situations have long histories, so one new direction to pursue is the idea of how these situations compare to one another, and what we can learn from looking at them collectively. Conditional probability is particularly nettlesome, and with the aid of simulations these can be convincingly approached, even if only for the sake of building a sense of belief in the power of the conditioning event.

Dr. Dan Canada

READING LIST

Batanero, C., Green, D., & Serrano, L. (1998). Randomness, its meanings and educational implications. *International Journal of Mathematical Education in Science and Technology, 29* , 113-123.

Bright, G., Brewer, W., McClain, K., & Mooney, E. 2003. (In S. Friel & P. House, Eds.) *Navigating through Data Analysis in Grades 6-8.* Reston, VA: NCTM.

Curcio, F. (1987). Comprehension of mathematical relationships expressed in graphs. *Journal for Research in Mathematics Education* , (18), 382-393.

Falk, R. (1988). Conditional probabilities: Insights and difficulties. In R. Davidson & J. Swift (Eds.), *The Proceedings of the Second International Conference on Teaching Statistics*, Victoria, BC: University of Victoria.

Konold, C., & Higgins, T. (2002). Highlights of related research. In S.J. Russell, D. Schifter, & V. Bastable, *Developing mathematical ideas: Working with data*, (pp. 165-201). Parsippany, NJ: Dale Seymour Publications.

Konold, C., & Pollatsek, A. (2002). Data analysis as the search for signals in noisy processes. *Journal for Research in Mathematics Education, 33*(4), 259-289.

Shaughnessy, J. M. (1992). Research in Probability and Statistics: Reflections and Directions. In D.A. Grouws (Ed.), *Handbook of Research on Mathematics Teaching and Learning*, (pp. 465-494). New York, NY: Macmillan.

Shaughnessy, J. (1997). Missed opportunities in research on the teaching and learning of data and chance. In F. Bidduch & K. Carr (Eds.), *Proceedings of the 20th Annual Conference of the Mathematics Education Research Group of Australasia*, (pp. 6-22). Rotorua, NZ: MERGA.

Shaughnessy, M., & Pfannkuch, M. (2002). How faithful is Old Faithful? *Mathematics Teacher*, 252-258. NCTM.

Shaughnessy, J., Watson, J., Moritz, J., & Reading, C. (1999). School mathematics students' acknowledgement of statistical variation. In C. Maher (Chair), *There's more to life than centers.* Presession Research Symposium, 77th Annual National Council of Teachers of Mathematics Conference, San Francisco, CA.

DANIEL L. CANADA, Ph.D.

Department of Mathematics
Eastern Washington University
Cheney, WA 99004

Telephone: (509) 359-6074
Fax: (509) 359-4700
Email: canada@cheerful.com

CURRENT OBJECTIVE

Fulbright Scholarship in mathematics or mathematics education

PROFESSIONAL EXPERIENCE

ASSOCIATE PROFESSOR (03 – Present)
[Eastern Washington University; Cheney, Washington]

- Teaching several courses for preservice teachers: All courses integrate content and methods
- Developing and refining curriculum in mathematics for teaching
- Advising students in the math education program
- Collaborating on grants, conference presentations, article writing, and ongoing research activities

RESEARCH ASSISTANT / MATH INSTRUCTOR (98-03)
[Portland State University; Portland, Oregon]

- Conducted research in math education as a part of two National Science Foundation grants
- Taught Precalculus, Calculus, and the following courses for mathematics teachers:
  Mathematics for Elementary Teachers (I and II)
  Arithmetic and Algebraic Structures for Middle School Teachers
  Problem Solving and Technology for Middle School Teachers

HIGH SCHOOL TEACHER (95-98)
[Seoul Foreign School; Seoul, Republic of Korea]

- Taught AP Statistics, Calculus, Geometry, Advanced Algebra, and Physical Science
- Chaired Math Department Committee for Curriculum Review

HIGH SCHOOL TEACHER (94-95)
[Emerson High School; Mount Vernon, Washington]

- Taught Algebra, Pre-Algebra, and Applied Mathematics
- Supervised individual learning contracts and senior research projects

COLLEGE MATH INSTRUCTOR (92-94)
[Western Washington University; Bellingham, Washington]

- Taught Intermediate Algebra, Business Algebra, and Precalculus
- Developed creative new ways of integrating graphics calculator into curricula

HIGH / MIDDLE SCHOOL TEACHER (89-92)
[Sanaa International School; Sanaa, Republic of Yemen]

- Taught Algebra, Precalculus, Computer, Physics, and Health
- Initiated use of graphics calculator into math curriculum

GRADUATE TEACHING ASSISTANT (88-89)
[University of Southern California; Los Angeles, California]

- Taught three lab sessions of Calculus
- Tutored calculus students during consulting hours

HIGH SCHOOL TEACHER (86-88)
[Heritage High School; Buena Park, California]

- Taught Algebra and Precalculus
- Tutored math students from high school

EDUCATION

Portland State University Portland, OR 97207	(98-04)	Ph.D. in mathematics education
Western Washington University Bellingham, WA 98225	(92-94)	M.S. in mathematics and WA State Teaching Certificate (Gr. 4-12)
University of Southern California Los Angeles, CA 90098	(88-89)	Graduate student in mathematics
Biola University La Mirada, CA 90638	(85-88)	B.S. in mathematics
University of the Pacific Stockton, CA 95211	(82-83)	Business major

HONORS

Graduated summa cum laude from Biola University
Received Dean's Fellowship at University of Southern California
Merit Award for Scholarship at Eastern Washington University (EWU)
Chairs' Award for Scholarship in College of Science, Health, & Engineering at EWU

CONFERENCES

2001	Annual Conference of the AERA	Seattle
2002	Annual Research Presession of the NCTM	Las Vegas
	Annual Northwest Mathematics Conference	Portland
2005	Northwest Association of Teacher Educators' Annual Regional Conference	Spokane
	United States Conference on Teaching Statistics	Columbus
2006	Hawaii International Conference on Statistics	Honolulu
	Annual Conference of the AERA	San Francisco
	Int'l. Conference on Teachings Stats (ICOTS7)	Salvador
2007	NCTM Research PreSession	Atlanta
	Annual Conference of the PME-NA	Lake Tahoe
2008	Annual General Session Conference of the NCTM	Salt Lake City
	Joint Study Conference of the Int'l Association of Statistics Education (IASE)	Monterrey

JOURNALS

Canada, D. (2007). Public Perception: New Math and Reform Mathematics. *Northwest Passage: Journal of Educational Practices*, 5(1), 51-64. Vancouver, WA: Northwest Association of Teacher Educators.

Canada, D. (2007). The Known Mix: A Taste of Variation. To appear in *Mathematics Teacher*. Reston, VA: National Council of Teachers of Mathematics.

Canada, D., Adolphson, K., & Gilbert, M. (2007). Ratio Triplets: Promoting Mathematical Discourse in the Middle Grades. To appear in *ON-Math*. Reston, VA: National Council of Teachers of Mathematics.

Canada, D., Gilbert, M., & Adolphson, K. (2007). Ratio Triplets: An Investigation into Mathematical Thinking and Discourse. To appear in *Mathematics Teaching in the Middle School*. Reston, VA: National Council of Teachers of Mathematics.

Canada, D., & Goering, D. (2007). Deep Thoughts on the River Crossing Game. To appear in *Mathematics Teacher.* Reston, VA: National Council of Teachers of Mathematics.

Goering, D., & Canada, D. (2007). The River Crossing Game. *Mathematics Magazine*, *80*(1), 3-15.

Middleton, J., & Canada, D. (2007). Fibonacci Scales & Melodies. To appear in *ON-Math*. Reston, VA: National Council of Teachers of Mathematics.

Canada, D. (2006). Enhancing Elementary Preservice Teachers' Conceptions of Variation in a Probability Context. *Statistics Education Research Journal 5*(1), 36-63.

Canada, D., & Blair, S. (2006). Intersections of a Circle and Square: An Investigation. *Mathematics Teacher, 100* (5), Reston, VA: National Council of Teachers of Mathematics.

REFEREED PAPERS

Canada, D. (2007). Informal Conceptions of Distribution Held by Elementary Preservice Teachers. In Woo, J. H., Lew, H. C., Park, K. S. & Seo, D. Y. (Eds.). *Proceedings of the 31st Conference of the International Group for the Psychology of Mathematics Education*, Vol. 2, pp. 73-80. Seoul: PME.

Canada, D. (2007). Variability in a Sampling Context: Enhancing Elementary Preservice Teachers' Conceptions. Paper Presented at the Research Presession of the 82nd Annual Meeting of the National Council of Teachers of Mathematics. Atlanta, GA.

Canada, D., & Ciancetta, M. (2007). Elementary Preservice Teachers' Informal Conceptions Of Distribution. In Lamberg, T., & Wiest, L. R. (Eds.) *Proceedings of the 29th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education* (pp. 960-967). Stateline (Lake Tahoe), NV: University of Nevada, Reno.

Gilbert, M., Canada, D., & Adolphson, K. (2007). Proportional reasoning: (Mis)conceptions of elementary preservice teachers. *Proceedings of the 29th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education.* Lake Tahoe, NV: University of Nevada.

Canada, D. (2006). Enhancing Elementary Preservice Teachers' Conceptions of Variation in a Probability Context. In A. Rossman & B. Chance (Eds.), *Working Cooperatively in Statistics Education. Proceedings of the 7th International Conference on Teaching Statistics.* Salvador, Brazil.

Canada, D. (2006). Enhancing Elementary Preservice Teachers' Conceptions of Variation in a Probability Context. In .Alatorre, S., Cortina, J.L., Sáiz, M., and Méndez, A.(Eds) *Proceedings of the 28th annual meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education.* Mérida, México: Universidad Pedagógica Nacional.

Canada, D. (2006). Variability in a Probability Context: Developing Preservice Teachers' Understanding. In Novotna, J., Moraova, H., Kratka, M., and Stehlikova, N. (Eds.) *Proceedings of the 30th Conference of the International Group for the Psychology of Mathematics Education.* Prague, Czech Republic: PME.

Canada, D. (2006). Conceptions of Variation: Comparisons of Data Sets by Middle School Students and Preservice Teachers*.* *Proceedings of the 5th Annual Hawaii International Conference on Statistics, Mathematics, and Related Fields.* Honolulu, HI.

Canada, D., & Makar, K. (2006). *Preservice Teachers' Informal Descriptions of Variation*. Paper delivered at the 2006 Annual Meeting of the American Education Research Association. San Francisco, CA.

Makar, K., & Canada, D. (2005). Preservice Teachers' Conceptions of Variation. In Chick, H. L., & Vincent, J. L. (Eds.) *Proceedings of the 29th Conference of the International Group for the Psychology of Mathematics Education*. Sydney, Australia: PME.

Shaughnessy, J. M., Canada, D., & Ciancetta, M. (2004). Types of Student Reasoning on Sampling Tasks. In M. Høines and A. Fuglestad (Eds.) *Proceedings of the 28th Conference of the International Group for the Psychology of Mathematics Education*. Bergen, Norway: Bergen University College.

Shaughnessy, J., Ciancetta, M., Best, K. & Canada, D. (2004). *Students' Attention to Variability when Comparing Distributions.* Paper Presented at the Research Presession of the 82nd Annual Meeting of the National Council of Teachers of Mathematics, Philadelphia, PA.

Ciancetta, M., Shaughnessy, J.M., & Canada, D. (2003). *Middle school students' emerging definitions of variability.* In N. Pateman, B. Dougherty, & J. Zillah (Eds.) *Proceedings of the 27th Conference of the International Group for the Psychology of Mathematics Education: Vol. 4.* Honolulu, HI: University of Hawaii.

Shaughnessy, J. M., Ciancetta, M., & Canada, D. (2003). Middle school students' thinking about variability in repeated trials: A cross -task comparison. In N. Pateman, B. Dougherty, & J. Zillah (Eds.). *Proceedings of the 27th Conference of the International Group for the Psychology of Mathematics Education: Vol. 4.* Honolulu, HI: University of Hawaii.

Peressini, D., Masarik, K., Adajian, L. & Canada, D. (2002). *Working with the Public to Improve School Mathematics: Parents' Views on Mathematics Curriculum Reform.* Paper presented at the 2002 Annual Conference of the American Educational Research Association. New Orleans, LA.

NON-REFEREED PAPERS

Canada, D. (2005). *Issues in Mathematics Education: Changing Perspectives of Preservice Teachers.* Address delivered to the Annual Regional Conference of the Northwest Association of Teacher Educators. Spokane, WA.

Canada, D. (2005). *Elementary Preservice Teachers' Conception of Variability*. Spotlight on Research Session at the United States Conference on Teaching Statistics. Columbus: OH. [Handout available online at http://www.causeweb.org/uscots/spotlight/research.php].

Canada, D. (2001). *Public Perception: New Math and Reform Mathematics.* Paper presented at the 41st Annual Northwest Mathematics Conference. Portland, OR.

EXAMPLES OF SERVICE ACTIVITIES

2007	- Editorial Board Member (NCTM's ON-Math Journal)
	- Chair of Mathematics Education Committee
	- Planning Committee of Mathematics Department
	- Head of Search Committee for Mathematics Education Position
2006	- Member of Search Committee for Dean of College
	- Judge in Undergraduate Research Symposium
	- Member of several Master's Oral Committees
2005	- University Liaison for Wash. State Math Council's H.S. Math Contest
	- Joint Presenter for Pi Mu Epsilon Math Club
	- Joint Presenter for Spokane Mathematics Colloquium

REFERENCES

Mike Shaughnessy, President-Elect of NCTM		
Portland State University	(503) 725-3624	(mikesh@pdx.edu)
Diane Dowd, Professor of Math Education		
Eastern Washington University	(509) 359-2876	(ddowd@mail.ewu.edu)
Christian Hansen, Chair of Math Department		
Eastern Washington University	(509) 359-6068	(chansen@mail.ewu.edu)